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# ***JPRS Report***

## **Soviet Union**

***AVIATION & COSMONAUTICS***

***No 3, March 1991***

19980506 015

**DTIC QUALITY INSPECTED 3**

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# Soviet Union

## AVIATION AND COSMONAUTICS

### No 3, March 1991

JPRS-UAC-91-008

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28 October 1991

[The following are translations of selected articles in the Russian-language monthly journal AVIATSIYA I KOSMONAVTIKA published in Moscow. Refer to the table of contents for a listing of any articles not translated.]

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## **Fundamental Change of Flight Training System Proposed**

*91UM0812A Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 91 (signed to press 19 Mar 91) pp 4-6*

[Article by Colonel V. Sobolev, deputy chief, Chernigov Higher Military Aviation School for Pilots, Military Pilot-Sniper, under rubric "Military Reform and Combat Training": "Stop Teaching in Retro' Style"]

[Text] Under conditions of market relations and growing acuteness of servicemen's social needs, only a cardinal change in the present flight personnel training system will allow the Air Force to shift to qualitative parameters of military organizational development. That is what Colonel V. Sobolev, deputy chief of the Chernigov Higher Aviation School for Pilots and a Military Pilot-Sniper, believes.

The reduction in numerical strength of the USSR Armed Forces, including aviation, presumes maintenance of the requisite level of combat readiness by increasing the role of the human factor: the efficiency and intensity of combat training of those who remain in formation. But even now one is ashamed to reproach people for deficiencies who are at their work places, the airfields, 12-14 hours a day.

Economic incentives will be able to correct the state of affairs only partially. An average worker with high pay will not be able to work excellently even though he tries. Therefore I see the way to qualitative parameters (along with economic and moral incentives) to lie in a new approach to training aviators and organizing their activity. Success of the matter always has been decided and will be decided by people, and with further democratization of society and the building of a rule-of-law state the Army collective can be made cohesive and put in the mood to accomplish missions at hand only by commanders who combine within themselves supreme professionalism, superior organizing abilities, humanness, and the best qualities of Russian officers: valor, honor, and dedication to their homeland. It is understandable that four years is an unrealistic time period for training such a specialist in flight school. This problem must begin to be solved as early as possible, when it is easier to fire up young people with the romance of the sky and captivate them with the profession of the military man.

The structure for training military pilots now taking shape presumes the following elements: a special boarding school with primary flight training or an air sports club; flight school (higher aviation school for pilots); air training center for conversion-training of flight personnel to a combat aircraft; line unit; academy; and in formation. Each element enumerated is subordinate to its own department and has its own training plans and programs. It accomplishes a closed cycle of specialist training to a level determined by his abilities. And each subsequent element must be the client for the previous

one, but in fact this is hampered by departmental barriers. It is at the boundaries between component parts of the training system, boundaries which have the property of extinguishing all initiatives in each of the elements, that colossal pilot training losses occur. For example, if a qualitative breakthrough in training flight personnel has been made in school, then the work of the air training center, line units and so on also must be restructured immediately in order to continue at a higher level with the job which has begun. But for this it is necessary to break up the already formed training process, and this is far from always done. As a result the principle that triumphs is "we don't care a bit about what you were taught earlier, forget it." As a result there is an extinction of all innovative initiatives which find no way for realization and turn out to be simply unnecessary. It follows that with existing expenditures a higher level of aviator training can be achieved only by creating a unified plan and program for all elements of the pilot training system or by reducing the number of elements in this system right down to one client and one performer.

Each approach has its advantages and shortcomings, and so proposals being made here to upgrade pilot training are based on their optimum combination and are limited to the first three elements of the system. Their essence lies in answers to four questions determining the didactic principles of training: "What should be taught?" "Who should be taught?" "How should it be taught?" and "Who should teach?" Well, then

### **What Should Be Taught?"**

It is obvious that, having taken the special boarding school and having completed the higher aviation school for pilots and air training center, a graduate must be evaluated along four directions: as an individual, a person of high culture and a citizen of his homeland; as a military pilot ready for immediate performance of assigned activity; as a future air commander, i.e., for the near term; and as a specialist capable of self-improvement over the long term.

For now the first direction has Cinderella rights—it essentially has been neglected. I understand that the process of an officer's development as a comprehensively developed individual is lengthy and has to begin as early as possible. Establishment of the special boarding school is a godsend; it permits adding another three years to the cadet training period in school. Development of a complete training and education program for them requires a separate discussion, and subsequently we will touch only on their professional training as pilots.

The second and third directions are implemented by training cadets in tactical, special tactical and specialized military disciplines and by general and specialized physical training. Air arm tactics and tactical air training are the "clients" for knowledge.

The other disciplines, including flight training elements, also are part of the base of knowledge, abilities and skills necessary for mastering the theoretical and practical parts of the tactics course.

The fourth direction presumes fundamental training with mastery of general engineering and general scientific disciplines.

#### **"Who Should be Taught?"**

The vast set of disciplines studied by a future pilot in compressed time periods dictates a high training load. Therefore the pilot training process is oriented toward an elite portion of the youth, the most developed young men possessing high intellectual potential. An active search for them throughout the country with subsequent enrollment in the boarding school is proposed. Here is where work is done for professional orientation and early development of qualities important to the pilot. At the same time, this does not disclaim acceptance in the higher aviation school for pilots of secondary school graduates, working youth and servicemen dreaming of becoming pilots and possessing good characteristics for this.

#### **"How Should It Be Taught?"**

In answering this question it is necessary to examine the entire training system not in the form of separate elements as is now done (schools, flight schools, centers, line units, academy), but in their interworking.

During the future officer's professional orientation and shaping of his personality in primary flight training schools (flight schools, lyceums, DOSAAF air organizations), a determination is made about who wishes to and can continue training in a military educational institution.

The higher aviation schools for pilots prepare the trainee as a serviceman, a pilot, and a future air commander and definitely determine his prospects for improvement. Here the graduate is legally declared to be a specialist with a diploma.

In case air training centers are incorporated in the overall Air Force structure, they become a transitional link between military educational institutions and line units, which react promptly to all changes in these system elements. Based on flight school recommendations, graduates receive conversion-training to combat aircraft in them and are distributed to air arms.

Further professional improvement of the pilot as an officer who is a tactical-level air commander occurs in Air Force line units.

There is academic education (Air Academy, General Staff Military Academy) for the most capable officers and generals to train air commanders for the operational-tactical, operational and operational-strategic levels.

It is quite obvious that training programs of all training stages must represent a single whole and be interconnected in such a way that there is a further buildup in the level of a pilot's comprehensive proficiency and so that the next stage is a logical continuation of the previous one.

Not a departmental, but a unified Air Force policy must be studied here, but this is absent for now. At the present time, for example, although special boarding schools prepare graduating students for the Air Force, they are under the purview of the USSR State Committee for Public Education. Therefore they are not always opened where there are flight schools.

The Air Force Directorate of Military Educational Institutions tries to distance itself from them by hook or crook, although flight schools, which legally are the clients for these boarding schools, require joint work with them under a unified, "start-to-finish" training and education program.

At the same time there is another paradox: air training centers are in the military educational institutions system although they train flight personnel for line units. Combat training in turn rejects these centers, since it already has a number of its own special ones.

For this reason I see no sense in air training centers, which mean a superfluous level, a management apparatus, lack of consideration of the previously achieved training level of young pilots, and shortcomings in theoretical and methodological accompaniment of training. It is more advisable for flight schools themselves to determine a graduate's prospects by having given him conversion-training to a modern combat aircraft. This can be done in the fourth course with intensive flight training.

#### **Who Should Teach?**

In the special schools and higher aviation schools for pilots, trainees are under the influence of three categories of teaching personnel: cadet subunit commanders, instructors, and instructor pilots. Under conditions of a cost effectiveness evaluation of activity, it is advisable to give the school leadership more rights to choose and approve candidates for filling these positions.

While matters are more or less satisfactory with the qualification of instructors and can be corrected with respect to cadet commanders, the most difficult training, flight training, is performed by the least trained teachers, the instructor pilots.

A qualitatively new level of training for graduates presumes a change in the instructor training system. Along with economic incentives, about which much already has been said recently, it presumes a higher level of pedagogic, flight and methods training and a practical knowledge of the missions and working conditions of Air Force line units, especially those engaged in training graduates.

It should be noted that such a program has been drawn up and already is being implemented in the school.

Just what do we see as the optimum variant of a training system for flight personnel at the level of Air Force military educational institutions? Above all it includes a new element, the special boarding school (9th, 10th and 11th grades), consolidated with the flight school by a single optimized training and education plan and being one of the training subunits of the higher aviation school for pilots. Along with providing a secondary education, this will permit precisely determining the purpose of each training year and promptly and fully preparing the student for comprehending the following stage of development.

In the 9th grade there is professional orientation and psychological and specialized physical training for flight operations. In the 10th grade there is a determination of prospects for further training as a result of 25 flying hours of training in the L-39. In the 11th grade there is special training for entry into the school for pilots, maintenance of flying skills (15 flying hours), and study of fundamentals of aviation disciplines. There are courses in ethics of an officer's conduct, esthetics and so on throughout the entire training period.

The first course at the higher aviation school for pilots is for shaping the serviceman and pilot (60 flying hours in the L-39): rehearsing flying techniques, air navigation, and formation flying. The second course is for forming the military pilot (90 flying hours): combat employment against airborne and ground targets, tactical air training of the crew and pair, and familiarization with the organization of flight and squadron combat operations. The third course is for forming the air commander (90 flying hours in the L-39): flight and squadron tactical air training, familiarization with the organization of regimental combat operations. The fourth course is for combat training program conversion-training to a combat aircraft and attainment of a given level of preparation for combat operations (70 flying hours in the MiG-29), and for taking state exams. The air training center is excluded here or is used as part of the school for training fourth-year students.

Leveling in training graduates is precluded. They are placed in one of three levels depending on abilities: basic—third class military pilot; higher—second class military pilot level; special—instructor candidates additionally master the technique of flying from the instructor's seat.

Implementing the concept requires a number of organizational measures including introducing elements of market relations during training, revising the graduate's qualification characteristics (the state order for a specialist) and general training and education programs, reorganizing training department chairs and so on.

We have been working on this problem in the Chernigov Higher Aviation School for Pilots on an initiative basis since 1981 and are performing scientific research and experiments within the framework of a unified concept.

Special emphasis is placed on upgrading the flight training process and raising the safety level of cadet flights.

During 1984-1985 we introduced training in coming in for a landing on a straight-in approach, from the point of commencing an initial approach descent, and with two 180° turns. The result was a reduction of 10 flights in the dual-instruction program, a significant decrease in the number of rough landings, and exclusion of instances of a loss of speed and stalling on the third and fourth turns.

In 1986 there was a return to previously prohibited training in night flying techniques and navigation. The quality of landings improved along with the overall level of proficiency.

In 1987 there was the beginning of cadet training in a trainer under a new program which included expert-level advanced aerobatic maneuvers; flying techniques, navigation and pair join-up under adverse weather conditions; intercepts singly and as a pair, and elements of combat maneuvering; and landings at alternate airfields and squadron tactical air exercises. As a result, despite the considerably increased complexity of flight missions, there was a drop instead of an expected increase in the number of erroneous cadet actions, which indicates the great capabilities young people have in reserve.

In the next year the very same training was conducted in the MiG-23 combat aircraft. Similar results were obtained, which confirmed that a pilot's reliability can and must be laid down in training as early as possible.

In 1989 there was flight training in a trainer under a new flight training course, which showed that cadet training in schools is possible to the level of third and even second class military pilot. A new program and new methodology of training in the air were rehearsed simultaneously on the MiG-21 combat aircraft with a reduction of demonstrations (AVIATSIYA I KOSMONAVTIKA, Nos 4, 5, 1990). As a result there were fundamentally new opportunities to improve pilots' professionalism. Last year this methodology was introduced in all the school's regiments. And in parallel with this a "flight training" training discipline was worked out which combined theoretical, simulator and flight training in a single whole; the optimum combination of theory with practice was determined; and there was training of young instructor pilots under the new system, and training of the first instructors from among flight personnel.

A prolonged professional-psychological selection of cadets, methodologies for forecasting the success of flight training and development of professionally significant trainee qualities, and a number of other matters were worked out and checked in practice during the past decade.

But it is impossible to accomplish the task of sharply increasing professionalism within the scope of officially

approved training plans, programs and flight training courses, since they contain a low level of air proficiency and rigid restrictions on parameters of assignments performed both in training and in performance-graded flights. Even now, the low level of training which can be ordered for a graduate, which for many years led to a degradation of the entire training system, hampers forward progress.

What already has been implemented permitted increasing the reliability and consequently the proficiency and level of flight safety of flight and cadet personnel and of those on the flight operations team. But this is far from the limit of schools' capabilities if they work together with special boarding schools and air training centers within the scope of a unified system for training flight cadres. But for now, apparently, the new contingent of graduates of higher aviation schools for pilots also will be greeted with the words: "We don't care a bit about what you were taught..." So there will be no perestroika in isolation. The problem can be solved as a whole only at a level no lower than the Air Force.

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#### Flight Preparation Shortcomings Discussed

91UM0812B Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
pp 6-7

[Article by Guards Major V. Fomin, senior engineer of unit aviation engineering service, under rubric "Combat Training: Aviation Engineering Service Problems": "Seconds Equal to Years"]

[Text] *I am not writing to complain or to accuse someone. I understand how difficult it is for everyone now: command element, designers and aircraft enterprise personnel. Everything that was incompletely thought out or unfinished at one time hits every one of us painfully. And I am not writing to call for a hasty correction of everything without exception—we should not make a lot of new mistakes. I am calling in an unbiased manner, forgetting about the "honor of the uniform," for us to take a look at what we have, both the good and the bad, and through common efforts outline ways of emerging from the existing situation.*

We performed the regiment's assigned mission for the tactical air exercise. We were happy and congratulated each other. Nevertheless, the feeling did not leave us that there was much that could have been done both better and faster. There were many shortcomings both in organization and in support of the combat training activities. I hope that by highlighting them, we are not the only ones given abundant food for thought by the tactical air exercise.

...The signal which sounded seemed to have aroused half a rayon, but was it only the residents necessary? At one time it was simple to get needed information to aviators; military compounds were built compactly and as close to

airfields as possible so everyone was at hand and could assemble rapidly at a signal. But gradually aviation compounds became semi-military in the best instance; many living in them either had lost contact with aviation or never had it. This is why, due to the impossibility of obtaining quarters in their own "eagle's nest," many officers and warrant officers seek at least some kind of housing in neighboring villages and settlements. No matter how difficult it may be, it is probably necessary to do everything to see that people live compactly, for this affects the military collective's combat readiness and cohesiveness in a most direct manner.

For a long time now the count has been not in seconds, but minutes. Finally the majority of specialists are assembled. Where are the vehicles? We don't even dream of buses: there are only enough of them to transport the pilots. That's fine. They now have to fly to the maximum radius, and let them not waste energy in vain or be jolted in trucks. We understand, but nevertheless would like to become equal at least sometime, for we too have difficult work ahead on which much depends. But then, here are our trucks. Fears confirmed: just half of the required number. That means we will transport the people again in two or three trips. But time is going by. Never mind, our people are golden, our people are iron—they will make up the time! They are accustomed to waiting and catching up.

Finally we are at the airfield. The mission and aircraft preparation variant is made known to the personnel through squadron chiefs of staff. Everything has been rehearsed and each person performs his duties; and others' duties as well. Freezing temperatures, wind, late night. Teams clear the flight lines and taxiways of snow by hand and remove heavy covers from aircraft. There is clearly a lack of working hands. No, everyone who was supposed to, arrived in the alert. There simply are no others; we are almost one-third under-strength. It is necessary to take a careful look at the procedure for manning units: Is everything being done as it should be? It is a great pity that they stopped sending us civilian university graduates, the "two-year men." This is probably proper from a certain standpoint, but we have a very great lack of these specialists, who for the most part are competent and conscientious. The fact is, each year no more than half of the necessary number of young officers come from military schools; moreover, many of them already have a request for discharge instead of a marshal's baton in their "soldier's haversack." But what can a regiment give novices except difficult work? Because of everyday disorders, many of those who remained to serve cannot devote themselves to service as they would like and as they could. For long years funds basically were put into aircraft. But what are they without people? It is well that everyone now is beginning to understand what this develops into.

Using automatic starting assemblies and mobile hydraulic units adapted as prime movers, rear specialists bring up heavy trailers with the basic unit of fire to the aircraft. Again, they have to be shoved under bomb

hatches by hand. Today things were quite bad: the concrete was covered with a crust of ice and feet slipped. There were 2-3 teams near each dolly; there was no other way to cope. And again there was occasion to regret that were they self-propelled, the specialized vehicles and many of the crew members already long ago would have been taking a direct part in preparing equipment. But for now again seconds and minutes were going by.

Technical crews of aircraft and technological groups finally began performing their immediate duties, but as always there were not enough automatic starting assemblies. We started auxiliary power units from those we did have. We are of course saving time, but we realize that by using auxiliary power units often, we are cutting off the branch on which we are sitting: no service life remains for some of the units. And what will we take in replacement? Probably it is time to more widely introduce aircraft electromechanical units: it will be possible to save both time and the service life of onboard units, and enormously fewer automatic starting assemblies will be needed—only just in case, as a reserve.

It is not said for nothing that communications represents the nerves of the Armed Forces. There are few Romashka radios and it is inconvenient to use those we have under our conditions: nothing is heard if there are blast walls between subscribers, and not everything can be said over the radio. But distances at long-range aviation airfields are large—shouting cannot be heard. Because of the absence of reliable communications, work progress reports are delayed and it is very difficult to maneuver equipment and specialists. Our innovators themselves upgraded the system for communicating information as best they could; nevertheless, well thought out, developed and convenient loudspeaker communications should be installed centrally at permanent airfields. I believe that authorized bicycles as well as small motor transport equipment also would help save time. By the way, of course the innovators too have done far from everything they could, and not just in upgrading communications.

There is a hitch on one of the aircraft: a failure in the bombsight and navigation system. We find the last serviceable unit in the technical kits, which have become considerably "leaner" of late. But what if yet another one fails? Then it will be necessary to urgently "undress" an aircraft standing there for modifications. But what can be done? Each year spare parts deliveries become worse, requisitions have been incompletely satisfied for a long time, more and more of our time goes to replenishing replacement stocks, and it becomes more and more difficult to repair units which have failed. We are holding out for now, but we are already hanging by a thread. The spare parts supply probably is the greatest bottleneck now and additional funds obviously have to be allocated to expand their production. What do new aircraft mean if there is nothing to keep them in a serviceable condition?

Finally the checks are completed. Manipulating cable winches, the team raises bombs into hatches. There are seven persons in each team, but we could get by with a lesser number if there were hydraulics on the dolly. But then all bombs have taken their places in the aircraft hatches. The flight crews accept the equipment from the ground specialists and the combat aircraft taxi to the start on command. We look at our watches: we made it!

There are a few minutes to rest a bit, warm up and receive a new mission. We too now are to take off, as we are being rebased to an alternate airfield. Unfortunately, support of the rebasing has not been completely thought out. While we can carry essentially everything necessary on the ground (true, not that rapidly), since there are mobile monitoring and maintenance stations on vehicular chassis supporting almost all kinds of work, each unit on its own creates an airmobile version of the technical maintenance unit for itself. Our unit is no exception. Initially we made it on the basis of homemade metal boxes, then we adapted heated vehicle bodies equipped with shelves. We ourselves also fabricated collapsible, fully transportable ladders, since the authorized ones convenient only at a permanent airfield cannot be carried with you. Of course, we make do, but we begrudge time which has to be spent remedying others' incomplete work.

...Again fewer transport aircraft are assigned than prescribed and it is necessary to reorganize on the move in deciding what to take along. As always, we load inflated assembled tires, because the unit for installing them is heavy and not adapted for transportation. And we load tow bars without fail. It would be well to have them at the alternate airfield permanently, but there is a shortage of these seemingly simple beams on wheels at the main field as well. If only a general-purpose tow bar would be created for all types of heavy aircraft! The degree of ground equipment standardization of course must be enormously higher.

It is necessary to cram as much as possible into the transport aircraft from the set of spare parts, instruments and accessories, for whatever has not been included definitely will fail. At the last tactical air exercise a single-phase voltage converter on one of the bombers failed, something which we did not have along. We had to send a vehicle to the adjacent airfield for it. The takeoff of the combat aircraft was delayed for several hours. It is well that it is peacetime.

This time we were lucky: we took specifically what was necessary and we also worked normally at the alternate airfield. Normally? Yes, for those conditions under which we work and live. Say what you like, but the "requirements bar" (everyone understands this) is set so that we nevertheless might have a chance of "jumping over," albeit with enormous strain. But a real confrontation, which one would like to believe will not happen but for which we must prepare with all seriousness, may demand both faster and more effective actions.

Of course, much depends on us, but the fact is, preparation for combat begins not at the alert signal, but enormously earlier. Battle is a test not only for flight and technical personnel, but also for many thousands of specialists—scientists, designers, production personnel and personnel of ministries, educational institutions, staffs, and rear and administrative entities, military and civilian—since all of us depend on each other. Years of common labor are compressed into each of the seconds required for preparing aviation equipment for takeoff. And the more that is put in and the better our work is supported, the fewer of these so dear seconds which determine victory or defeat that are needed, both in training and in battle.

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### Peacetime, Wartime External Visual Observation by Pilots Analyzed

91UM0812C Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
pp 12-13

[Article by Lieutenant-Colonel of Medical Service V. Kozlov, candidate of medical sciences, under rubric "Flight Safety: A Specialist's Advice": "Teach External Visual Observation Professionally"]

[Text] The attack was completed successfully. After turning to the final target heading, Major A. Volkov, Mi-24 helicopter commander, executed aiming at the prescribed distance and precisely bracketed the ground target with free-flight rockets. There also were no deviations in the flight configuration. It would appear that the result was excellent and there could be no complaints about the pilot. In fact, there are no complaints about a pilot's actions with existing approaches to the organization and evaluation of range combat activities. But in this instance a research flight was being made and there was a monitor-recorder in the helicopter which allowed recording the direction of the pilot's gaze, among other indicators.

An analysis of data showed that on the target run the pilot's attention was distributed among three main information sources: the space outside the cockpit in the direction of flight, the sight, and the instruments. That structure ensured precisely maintaining the flight configuration and hitting the target, but at the same time it showed that the pilot did not accomplish or, more precisely, did not include in the algorithm of his activity one of the most important tasks, especially in real battle—external visual observation.

Some may object that there was no great need for that, and so the pilot did not turn his head. Yes, that is so, but what will happen if a pilot also begins to act in a combat situation just as he is accustomed to do at the range?

Let us examine this question in more detail.

With all its seeming completeness, a pilot's in-flight activity nevertheless consists of individual components, each aimed at accomplishing a specific task. One of the basic ones is external visual observation, and it is distinguished by a number of features.

First of all, while not directly related to precision of piloting and effectiveness of employing weapons and with other conditions being equal, the quality of external visual observation determines to a considerable extent whether or not the mission will be performed (especially in a combat situation). Secondly, two motives of the pilot which influence flight safety, which means also accomplishment of the combat mission, intertwine here most distinctly: biological (preservation of life) and social (performance of the assignment). Thirdly, external visual observation is characterized on the one hand by relative simplicity of the actions performed and on the other hand by the need for a large time reserve in order to ensure all-around, continuous, deep study of space outside the cockpit. The important thing here is to forecast rather precisely the air and ground situation, which can change and become complicated at any moment. Fourthly, like no other task, external visual observation has substantial differences in making flights in peacetime conditions and in a combat situation.

External visual observation assumes special importance under combat conditions. Here is how Marshal of Aviation I. Kozhedub, Triple Hero of the Soviet Union and famed Great Patriotic War pilot, told about this concisely but capaciously in his book "Vernost Otchizne" [Allegiance to the Homeland]: "External visual observation, and external visual observation once more—turn your head 360°." By the way, pilots who performed international duty in Afghanistan also agree fully with this opinion.

Let us examine the psychophysiological aspects of this flight component in the cross-section of today's combat pilot training. Above all let us clarify just what is meant by conducting external visual observation. One method aid gives the following definition: "External visual observation consists of the actions of a pilot or crew aimed at obtaining information about the air situation (visually or with the help of radiotechnical equipment)." It is noted further that "the purpose of external visual observation is prompt detection of the enemy under combat conditions and assurance of flight safety in peacetime."

A psychophysiological analysis of this definition permits singling out three points in it with which it is difficult to agree. First of all, external visual observation is viewed as an action and not as an independent activity, which is fundamentally reflected in flight personnel's attitude toward it in the professional training process. Secondly, to ensure flight safety a pilot needs information not only about the air, but also the ground situation, but nothing is said about it. Thirdly, external visual observation under combat conditions and in peacetime is separated. This obviously is legitimate, but a reasonable question arises: How is it possible to prepare to conduct external



visual observation in real battle if a different purpose is pursued in performing training flights?

And so without laying claim to truth in the final instance, I believe that external visual observation is an activity with the distinct predominance of the sensory component aimed at prompt detection and recognition of an object outside the cockpit which can disrupt the flight safety of an aircraft or the aircraft's movement along the ground, and aimed at subsequent performance of a necessary maneuver and other actions in case it is detected. Among objects hazardous to flight outside the cockpit are ground obstacles, birds, other aircraft, enemy air defense weapons (both ground as well as airborne) and so on. The space outside the cockpit, radiotechnical equipment, and sets warning about the aircraft's irradiation serve as information sources.

External visual observation is possible by two methods from a psychophysiological standpoint. In the first method a search for objects threatening flight safety is made purposefully and conscientiously. In the second, objects are detected by chance while inspecting the space outside the cockpit to accomplish other tasks. Both methods have the right to exist, but while the former is typical of experienced pilots, the latter is basic for flight personnel without high professional training and attests to the absence of attention reserves necessary for accomplishing tasks not connected with flying the aircraft.

Inasmuch as external visual observation is an activity, like any other activity, on the one hand it has its specific subject—detecting an object outside the cockpit capable of disrupting flight safety and taking steps to prevent a collision with it; on the other hand, it requires certain professional training which includes acquiring appropriate knowledge as well as forming necessary skills. Knowledge includes information about the most dangerous areas and methods of conducting external visual observation in different stages of flight; information about those objects outside the cockpit which can disrupt flight safety (this includes data on the ornithological situation, natural and

man-made obstacles, features of organizing and performing flights in the vicinity of an airfield and along routes, air defense weapons being used by the enemy and their distinguishing signs, nature of maskirovka [lit. "camouflage", however, includes "concealment" and "deception"—FBIS], locations and so on); and methods of preventing collisions with objects outside the cockpit in case they are detected at an unsafe distance.

And skills in turn should be understood to mean skillful use of rational methods of performing external visual observation depending on the stage of flight and the situation outside the cockpit; monitoring the ground and air situation with brief visual fixations, which reduces time and enables combining external visual observation with the accomplishment of other tasks; and finally, actions to prevent collisions with objects outside the cockpit.

It becomes clear from what has been said that there is no difficulty obtaining necessary knowledge on conducting external visual observation under peacetime conditions, but applied to a combat situation. At the same time, it is essentially impossible to develop specific skills as well as form a rational structure of activity as applied to a combat situation without simulating the latter. External visual observation in conventional flight and in battle has fundamental distinctions (see table); therefore it is important to emphasize that performance of flight operations in the course of planned aviator training leads to forming an irrational structure of activity (from the standpoint of ensuring safety in a combat situation), since under peacetime conditions, where it is possible not to burden oneself with external visual observation (usually ground services create hothouse conditions for performing assignments), the pilot uses the time saved for flying, orienting himself, and so on. As a result, he forms abilities to accomplish those tasks designed for an increased time reserve. But in actual battle, especially over rugged terrain, in the mountains, and in a zone of opposition of enemy air defense weapons, the scope of attention devoted to external visual observation grows considerably and the time set aside for performing other tasks is sharply reduced. I will note that a fundamental change in structure of a pilot's activity as a whole is the consequence of that redistribution of visual observation time.

**Features of Conducting External Visual Observation**

No	Indicators	Conditions	
		Peacetime	Wartime
1.	Possibility of ground services providing safe flight conditions	Present	Absent
2.	Objects presenting greatest danger for a flight	Birds, ground obstacles, other aircraft	Enemy aircraft and ground air defense weapons
3.	Sector in which surprise appearance of objects hazardous to flight most probable	270°-90°	90°-270°
4.	Monitoring of space outside the cockpit	Uneven (rear hemisphere rarely monitored)	Even for all zones of both hemispheres
5.	Stages of flight at which appearance of objects reducing flight safety most probable	Takeoff, landing, extremely low altitude route	Route sectors beyond front line (especially target area)
6.	Time devoted to external visual observation	Up to 50 percent	Up to 100 percent

Thus, while with sufficient time (in peacetime conditions) a pilot has an opportunity to refer to instrument readings often in accomplishing a particular mission, he does not have that opportunity with the time deficit connected with the conduct of external visual observation (combat situation) and is required to shift to piloting based on noninstrument data not requiring him to shift his gaze from the space outside the cockpit to the instruments in the cockpit. It is difficult to accomplish that transition instantly. Therefore a new structure of activity forms in the first combat sorties which has a negative effect both on effectiveness of combat employment of weapons and on flight safety. This means that in order to prevent the pattern uncovered in the activity of a pilot in making the transition from flights in peacetime conditions to flights in a combat situation and reduce to a minimum the negative points of the transition period, it is necessary to simulate features of actual combat conditions in the process of day-to-day flight training.

Improving the models of a pilot's activity in studies conducted on benches, simulators and in actual flights is an important aspect of his proper understanding of the importance of a task such as external visual observation. Excluding the task of external visual observation from the model has a negative effect on the structure of pilot activity being formed and consequently the characteristics obtained here cannot always conform to true ones. Unfortunately, commanders often forget this in organizing subordinates' training and as a result the professionalism of combat pilots suffers.

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### Crime Rates in the Armed Forces

91UM0812D Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
pp 18-19

[Interview with Lieutenant-Colonel Gennadiy Valentinovich Drozdov, senior instructor of the Military Institute Chair of Criminal Law and Procedure, Candidate of Juridical Sciences, by AVIATSIYA I KOSMONAVTIKA correspondent; occasion, date and place not specified; under rubric "Law and the Armed Forces": "Crime in Uniform: Causes and Effects"]

[Text] *Crime in the Armed Forces does significant material and moral damage to them, affects unit and subunit combat readiness and combat effectiveness, and strikes painfully at Armed Forces' authority. Where did this evil in military collectives come from? Is it possible to fight it effectively? Our correspondent talks about this with Lieutenant-Colonel G. Drozdov, senior instructor of the Military Institute Chair of Criminal Law and Procedure, Candidate of Juridical Sciences.*

[Correspondent] Gennadiy Valentinovich, under the influence of the boom in writing, television broadcasts, and now also movies, many people are getting the impression that previously there was no crime in the Armed Forces,

that it appeared and is growing under conditions of perestroika. Do you share that opinion?

[Drozdov] Unfortunately, this is a widespread, dangerous delusion. It is based on practice of the stagnant period when the Armed Forces were considered to be a zone outside of glasnost and beyond criticism. Negative phenomena impossible to conceal were passed off as isolated and chance phenomena. The slogan "Armed Forces and crime are incompatible concepts!" served as ideological substantiation for the imaginary well-being. Meanwhile, morals and manners of the criminal world were being implanted in the barracks of some units.

People of course would like to entertain the illusion that there should be no crime in the Armed Forces, but it was there, is there, and will not fully disappear in the foreseeable future. And today the task of every one of us—commander, political officer, lawyer, psychologist, sociologist, journalist—is to look into the reasons for changes occurring in the structure and dynamics of crime in an honest, unbiased manner and find effective forms and methods to reduce it.

[Correspondent] Is it realistic to speak about this with the present very complex criminogenic situation?

[Drozdov] Speaking alone will make little sense. We must act. For example, although the campaign to fight non-regulation relationships did not fully solve the problem, it contributed to an appreciable 40 percent reduction in the number of recorded crimes of that nature from 1984 through 1989. The rates of reduction slowed in 1989, and a growth in crime again is noted in 1990. Many reasons can be given for this surge, but one of them unquestionably is connected with a let-up in work by some commanders and political officers and a reduction in activity of the Armed Forces public to make military collectives cohesive and to establish regulation procedures and a healthy moral and ethical microclimate. Many unfortunately simply have lost heart or have continued trying to achieve the goal by old methods. But appeals do not always work to the extent for which they were designed.

With respect to my optimism, it is based on an indisputable fact: despite the difficult time being experienced, the Armed Forces have been and remain one of the most integral, cohesive and socially healthy structures of our society.

[Correspondent] Nevertheless, negative processes and phenomena in society also affect the Armed Forces directly or indirectly.

[Drozdov] It was Marx who noted that "the entire history of civilian society is summed up with astonishing clarity in the history of the Armed Forces." Our reality of today confirms this pattern.

Crime in the country is growing at rapid rates. It increased by 31.8 percent in 1989 compared with 1988. Its growth rates in the first half of last year were 14.6

percent compared with the very same period in the previous year. A certain reduction gives no grounds for calm. For now our crime curve is crawling upward more steeply than in other countries. There are many reasons, and a rather great deal was said about them at congresses of people's deputies and sessions of soviets, in the press, over radio and on television.

With respect to crime in the Armed Forces, the crime statistics of military justice entities remain classified for now and I have no opportunity to work with specific indicators characterizing the structure and dynamics of crimes being committed by servicemen. But it can be said boldly that we still are far from well-being here, including in the Air Force. Colonel of Justice L. Smertin, a Main Military Procuracy representative, cites the following data in the journal *AGITATOR ARMII I FLOTA* (No 23, 1990). Last year 37.9 percent more crimes were registered in the Soviet Army and Navy than in 1989, and every fourth one was a grave crime. The number of premeditated murders rose by 20.3 percent and intentional infliction of serious bodily injury rose by 35 percent.

Specialists in the sphere of military criminology (the science of reasons for crime) long ago drew an unequivocal conclusion: basic reasons for crimes in the Armed Forces do not differ substantially from the reasons for crime in the country, while certain features are dictated only by their unique refraction by specific conditions of servicemen's life, everyday routine and activities.

Studies show that servicemen's crimes make up an insignificant proportion in the overall structure of crime, but trends in crime dynamics have common patterns. In other words, if crime drops in society, it inevitably also drops in the Armed Forces, and its growth immediately affects the criminogenic situation in the Armed Forces.

There is nothing terrible in this inasmuch as the Armed Forces cannot be partitioned off from society by a "Chinese wall." Young replacements come into the Armed Forces from the civilian environment twice a year. The callup of young men for military service does not relieve all problems, inasmuch as particular negative moral and ethical lines existing in the awareness of yesterday's schoolchildren, vocational-technical school pupils and workers do not disappear in an instant. Of course, there is an orderly system of military education functioning in the Armed Forces, but it hardly can immediately solve problems of re-educating persons contaminated by legal nihilism and other social ailments.

**[Correspondent]** The deterioration in the quality of the draft contingent is noted not only in construction and railroad units, but also in the Air Force, where until recently there was at least some kind of professional selection. Now that opportunity essentially is not there. How can this situation be explained and how does it influence crime in the Armed Forces?

**[Drozdov]** The specific nature of demographic processes now occurring does not permit proper selection of

drafttees. Young people previously convicted for crimes now often are called up for military service. For example, in 1989 25 percent of drafttees had been picked up by the police, and 6.6 percent had previous convictions. Crime among 17-year-olds is four times higher than among those over 30. But the most troubling thing is that this process is very dynamic. Each year the militia places approximately 300,000-350,000 juveniles on report. The number of juvenile transgressors delivered to militia entities annually already has approached a million. The opinion is substantiated that negative processes are being introduced to the Armed Forces environment to a considerable extent by those persons which make up the Armed Forces.

**[Correspondent]** Just how does crime in the Armed Forces differ from crime in our society?

**[Drozdov]** What has been said does not mean that crime in the Armed Forces copies crime in society exactly. That cannot be for the following reasons. Servicemen are assigned specific additional duties which civilians do not have; hence the features of criminal liability of citizens in military service.

The Law on Criminal Liability for Military Crimes adopted back on 25 December 1958, but which subsequently underwent changes and additions, is in effect at the present time. The draft of a new law now has been prepared and soon is to be discussed in the USSR Supreme Soviet.

Military crimes make up a large portion of the structure of servicemen's crimes. They include violations of regulation relationships in the Armed Forces environment for example. The proportion of these crimes presently is decreasing, but statistical data serve as poor consolation here. Chief Military Procurator Lieutenant General of Justice A. Katusev correctly notes that statistics simply do not reflect the actual state of affairs inasmuch as a significant number of facts of nonregulation relationships are concealed by the command element of units, and victims of "dedovshchina" at times are forced to leave their duty station and seek protection in various state and public organizations.

Offenses under ordinary law in the Armed Forces also differ in substantial features. Extremely negative trends have been observed lately. There has been an increase in the number of weapon and ammunition thefts. Stolen weapons often are resold to members of criminal groupings and are used by them in committing grave crimes. Servicemen also have begun committing crimes which previously were not encountered in the Armed Forces. One can include here the so-called racket (i.e., extortion of citizens' personal property) as well as other grave criminal acts.

**[Correspondent]** In your view, what factors contribute to a reduction in the number of crimes in the Armed Forces compared with general civilian conditions?

[Drozdov] A number of factors operate under Armed Forces conditions which neutralize certain negative processes, particularly offenses under ordinary law, the level of which is enormously lower than in society. First of all, there are features of servicemen's life, everyday routine and activities, where the personnel's high efficiency, constant monitoring of servicemen on the part of appointed persons, and detailed regulation of military relationships by military legislative measures are characteristic. Secondly, a rather effective system of military, legal and moral education of personnel functions in the Armed Forces. Thirdly, first-term servicemen are provided with all kinds of allowances necessary for satisfying vital requirements. Fourthly, there is the presence of a system of officer selection in the Armed Forces which permits ensuring an influx of the foremost part of society to military service.

These and other circumstances contribute to a reduction in crime in the Army and Navy and have a positive effect on motivating servicemen's behavior.

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### G-Load Limitation Calculations Compared

91UM0812E Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
p 19

[Article under rubric "Practical Aviation Work": "Are G-Load Limitation Charts Compatible?"]

[Text] In studying flight theory pilots learn that normal g-load ( $n_y = Y/mg$ ) is limited by the permissible angle of attack at slow speeds and by the strength of the aircraft wing at high speeds (Fig. 1). But there is one discrepancy here. While the angle of attack limitation is examined in a speed coordinate system, the strength limitation is examined in a body axes coordinate system (Fig. 2).

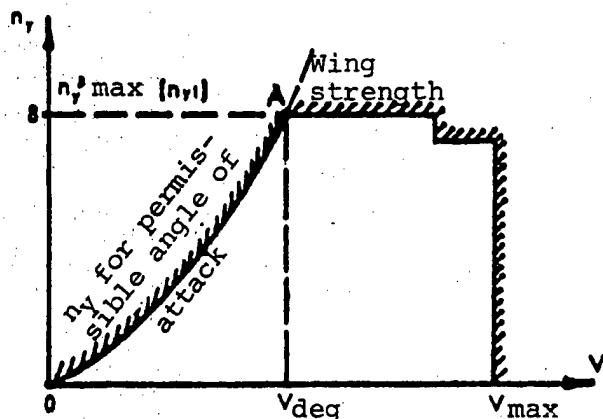


Fig. 1

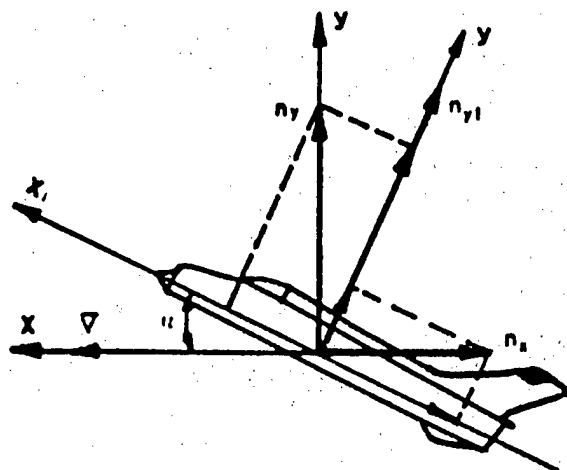


Fig. 2

Are the g-loads at point A (Fig. 1) equivalent for the same flight configuration in different coordinate systems? To answer the question, let us perform calculations applied to the MiG-21 aircraft. At boundary speed with a permissible angle of attack of 24°, normal g-load equals 8 and tangential g-load  $n_x = -4.2$ . At this point let us compute the g-load in a body axes coordinate system ( $n_{y1}$ ):

$$n_{y1} = n_y \cdot \cos \alpha - n_x \cdot \sin \alpha = 8 \cdot 0.9135 + 4.2 \cdot 0.4067 = 9.016$$

And so there is a different g-load value at the same point! And so, is the generalized aircraft g-load limitation chart cited in textbooks for flight personnel incorrect?

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### Causes of Excessive Aircraft Rolling Analyzed

91UM0812F Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
pp 21-22

[Article by Colonel N. Litvinchuk, candidate of technical sciences, under rubric "We Analyze a Near-Mishap Situation": "Why Did Excessive Rolling Arise?"]

[Text] A dangerous in-flight near-mishap situation resulted from the crew's scornful attitude toward observing rules for operating aircraft, absence of precise interworking of instructor and cadet in an emergency situation, and manifestation of the "associated mass effect"...

Cadet V. Yelfimov was making a performance-graded flight to the practice area in a MiG-21u trainer. His readiness for a solo training flight was being determined. The aircraft obeyed his confident actions, although he

sensed a heightened reaction to deflecting the aircraft control stick, but he had been warned about this by his comrade, who had made the previous flight in it. The instructor also was satisfied: taking over the controls was not required.

An "involuntary" movement of the control stick toward the pilot occurred unexpectedly after a dive when he was taking the aircraft into a steep climb. The g-load rose vigorously to 6.2. In the following instant, when the stick went forward, the g-load sharply changed to -3.3. Intensive excessive longitudinal rolling arose. The pilots felt the control stick moving and hitting their hands.

Since the cadet's seat belts were loosened, he separated from the seat and was pressed to the cockpit canopy at the very first overshoot of the negative g-load. The stick was torn from his hand and the parachute simultaneously separated from the seat, subsequently hampering stick movement and helping stop the oscillations. After this the trainee put his feet on the pedals and managed to get out of the seat bucket. He only partially succeeded in an attempt to put the parachute in place, which created certain difficulties in the landing.

The investigation of the very dangerous in-flight near-mishap situation helped determine its reasons: the switch for "ARU control"—automatic longitudinal control equipment—in the instructor cockpit was in a position in which the equipment did not function and during the entire flight it was on the large arm. In that case the aircraft becomes extremely exacting to fly at high speeds: maximum forces on the stick decrease from 28 to 8 kg(f) and contribute to the appearance of excessive longitudinal rolling.

The fact that in coming in for a landing and before lowering the landing gear at a speed of 600 km/hr the cadet saw the "Stabilizer for landing" panel lit up (attaching no significance to this) also serves as proof of a disturbance of the automatic equipment work mode. According to data of the check, the light should go out with instrument readings of no more than 490 km/hr.

The abrupt stabilizer movements at high instrument speeds registered by the flight data recorder system and the fluctuating (abnormal) nature of the change in g-load in the sector where aerobatic maneuvers are performed also are inherent to automatic longitudinal control equipment operation on the large arm.

Similar behavior of the aircraft with a g-load also had been registered in the previous flight for aerobatic maneuvers. This means that even prior to this pilots were flying with an introduced malfunction, but fortunately emerged from the situation safely.

Man's ability to adapt quickly to various conditions and the sufficient time for this from takeoff to the beginning of aerobatic maneuvers in the practice area permitted them to adapt to that aircraft's features. Mutual information passed among the cadets about the fighter's rigidity in longitudinal control did not help identify the

malfunction. Although they theoretically knew the signs for a malfunction of the automatic longitudinal control equipment system, they were unable even to surmise the reason for this phenomenon and believed it to be the norm, for the aircraft handled reliably and the ill-fated switch was in the instructor's cockpit.

The instructor pilot could easily have discovered the malfunction from the aircraft's behavior but, as is the custom when a cadet has good flying techniques and in the absence of complaints on the part of the trainee, he did not take hold of the control stick and was unable to prevent the abnormal situation from appearing.

Being attuned to large requisite forces and considerable play of the stick in shoving it away, the instructor acted in accordance with this mind-set at the moment of the intensive increase in g-load on entering the steep climb. For actual conditions the displacement of controls substantially exceeded requisite displacement, which led to going to the large negative g-load. In such cases the "pilot-aircraft-environment" system becomes inclined to excessive rolling inasmuch as a certain disturbance threshold is exceeded. Such situations are facilitated by the shortage of time which accompanies check pilots; they barely have enough time between sorties for critical comments, an entry in the cadet's logbook and getting seated in the cockpit of yet another aircraft. And so it goes day by day, many times during a flight operations shift: the plan must be fulfilled.

Other points of this in-flight near-mishap situation also require explanation, such as the "arbitrary" movement of the control stick, its blows against the hand, auto-oscillations and so on. It is apropos to note that a systems check confirmed their full serviceability and the aircraft was given a post-maintenance check flight without criticism.

Repeated mention already has been made about such phenomena as an "arbitrary" pull of the stick toward the pilot. The so-called "associated mass effect" (AVI-ATSIYA I KOSMONAVTIKA, No 12, 1985) may be one of the reasons for this under g-load conditions; this is when inertial force from the pilot's hand which he does not feel causes unintentional displacement of the control stick. When the automatic longitudinal control equipment is in the "high speed" position the requisite forces for its deflection are so great that the influence of this effect essentially is not felt. But if it is in the "low speed" position, then at high speeds the gradient of inertial force increase is higher than the gradients of g-load forces, especially if the fighter is a two-seater and both crew members are holding the controls. This leads to where pressing forces appear in place of pulling forces that would be presumed to be felt. One only has to be distracted, for example, by an increase in engine thrust, and the stick can "pull" toward you.

Just what is the reason for the seeming displacement of the control stick around the cockpit and its blows against the hand with the aircraft's excessive longitudinal rolling

at a time when according to flight data recorder recordings this is not observed? The essence of the phenomenon is as follows. A pilot usually determines the position and displacement of controls with respect to his body, but the pilot begins to move relative to the cockpit under conditions of the effect of sign-variable g-loads and accelerations. For example, with a large positive g-load he displaces toward the seat back and is pressed to it. If a negative g-load is acting, he rises upward and is thrown forward. In this case it seems to the pilot that an immovable control stick is moving, to which the crew members directed attention in the investigation. It was when the cadet began to be lifted to the cockpit canopy under the effect of a negative g-load that the control stick grip began to pull downward and toward him with respect to his body and was subsequently "torn" from his hand.

This is the phenomenon that contributes to the aircraft's excessive rolling. Let us imagine that in fulfilling requirements of the instructions under conditions of longitudinal oscillations, the pilot tries to hold the control stick in place with respect to his body. When he is pressed to the seat back under the effect of a positive g-load, the control stick will displace toward him. With a negative g-load it is the reverse, away from him. Here the "associated mass effect" shows up not from the hand alone, but from the person's entire body. The tighter the seat belts are drawn, the less mass that interacts with the control stick and the weaker the influence of this effect.

A pilot's actions to block unintentional stick displacement and the change in g-load usually are late, since in addition to the controlling movements he must compensate for the inertial forces of his hand and body that are changing in value and the force of friction in the control cable, and take into account his own delay. The magnitude of these forces is reduced as the g-load decreases and one observes a "falling" of the aircraft control stick, which aggravates the excessive rolling.

Someone may think that in the case in question the cadet's poor seat belt fit and the parachute falling from the seat bucket saved him from an in-flight near-mishap situation. This is partially so, but on the other hand, in case he needed to eject safely in this situation he no longer would have been able to do so.

But the main reason for what happened was a scornful attitude toward aviation equipment that had been operated for a long time, as reflected in its poor inspection prior to the flight. There was no proper monitoring of its working capacity in the air as well.

Established traditions where instructors fly in different aircraft and are sure that the previous teacher left a ready workplace after himself contributed to the in-flight near-mishap situation. It was learned that the toggle switch

was unintentionally switched by one of the cadets in practice drill training prior to flight operations, and this went unnoticed.

Excessive longitudinal rolling in maneuverable aircraft with dual controls often arises due to a lack of coordination in actions of crew members. It is naive to think that pilots do this deliberately. The fact that there still are no workable recommendations for an instructor to take over controls in emergencies and for his precise interworking with the cadet even in ordinary training speaks of a great deal. Although it appears simple, this question has been studied poorly for now, but it already has cost and apparently still will cost the lives of many aviators. This is one of many interaction "boundaries" between aviation system elements. Only man's interaction with equipment has been recognized and is being studied by ergonomics on a limited scale in aviation as of the present time. It would appear that to increase flight effectiveness and safety it is necessary to officially recognize other "boundaries" as well, including "pilot-control system" under the effect of a g-load, "instructor-cadet," "pilot-aircraft technician" and so on. Disregard of this, particularly an attempt to lay the blame only on the pilot or the equipment, leads to unhealthy relationships between flight and engineering-technical personnel.

In essence, without eliminating the causes, it is impossible to get rid of the repetition of "errors" contained not only in man and in aircraft design, but also in the established (formed) procedure of functioning of the aviation system. The deeper we delve into these problems, the more reliably we can organize its work.

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### Figuring Lead Angle in Aerial Gunnery

91UM0812G Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
p 22

[Article by Colonel N. Krasnikov, candidate of military sciences, under rubric "For the Military Pilot's Arsenal": "Aerial Gunnery Formula"]

[Text] The modern fighter is outfitted with a sophisticated aiming system. As with any technical device, it has a certain margin of reliability and so it is impossible to exclude the probability of its failure or damage in battle. What should a pilot do in a situation where cannon armament is ready for use but the sight is an enemy, not a helper in aiming? Make a ram?

But why not use Great Patriotic War experience, when pilots successfully engaged the enemy using simple mechanical sights?

The difficulty of calculating lead angle in aiming by eye is that the gunner has to rapidly determine the target aspect angle ( $R_{tgt}$ ), the sine of the enemy aircraft's angle of approach in fourths, then determine its approximate speed in tens of kilometers per hour ( $V_{tgt}/10$ ) according

to the type of aircraft and by mental multiplication find the lead angle in thousandths of a radian ( $\Psi^T$ ):

$$T = (V_{tgt}/10)(4R_{tgt}). \quad (1)$$

For example, with a target flight speed of 600 km/hr and an aspect angle of 2/4 the gun sight center dot had to be moved ahead of it by 120<sup>T</sup>.

Experience showed the high vitality of this calculation methodology. Many German aces were shot down by our pilots because of skilled use of the formula with aiming by eye. But is it correct for our days?

Calculations prove that this empirical relationship works well only at fighter flight speeds of less than 600 km/hr and projectile velocities less than 2,500 km/hr.

Its general form is  $\Psi^T = (V_{tgt}/v_{av})1000R_{tgt}$ , where  $v_{av}$  is the average velocity of the projectile's flight to the target.

Target Angle of Approach	6°	12°	18°	24°	30°	37°	45°	54°	65°	90°
Target aspect angle in tenths ( $R_{10} = K/10$ )	1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	10/10

Then in the 800-1,200 km/hr range of speeds, aiming by eye and using the NR-30 cannon, for example, it is possible to calculate lead angle from the formula:

$T = 30K$ , where  $K$  is the numerator of the target aspect angle. Thus, a lead angle of 150<sup>T</sup> is required when the target aspect angle is 5/10 (1/2).

It is desirable to recall the times when aiming drills for flight personnel were organized using simple sight collimators against aircraft mock-ups at various aspect angles. This also can be used later with normal operation of equipment for coarse aiming of weapons.

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### F/A-18 Hornet Fighter-Bomber

91UM0812H Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
pp 34-35

[Article by Major A. Dementyev and B. Rybak under rubric "Foreign Aircraft": "Deck-Based F/A-18 Hornet Fighter-Bomber"]

[Text] In the spring of 1974 the U.S. Department of Defense accepted a Navy proposal to perform studies to create a relatively low-cost, lightweight multi-mission fighter which was to replace F-4 Phantom fighters and A-7 Corsair attack aircraft in the Naval Aviation and Marine Corps Aviation inventory. The program for creating the

With a speed increase of the attacking aircraft, the actual  $v_{av}$  will increase and calculations for relationship (1) will give an inflated lead angle. Thus with a fighter speed of 1,000 km/hr, target speed of 800 km/hr and its aspect angle 2/4, an error of  $\Delta\Psi = 50^T$  will appear.

Therefore the following expression must be used for calculations at aircraft speeds of 800-1,200 km/hr:

$$T = (V_{tgt}/10)3R_{tgt}.$$

Among the parameters, the greatest error in determining lead angle is produced by inaccuracies in estimating aspect angle and target speed. Aspect angle plays a major role here. For example, using the NR-30 cannon at 1,000 km/hr an inaccuracy of only 1/4 in estimating it provides the very same deviation in lead angle as the error in determining target speed at 500 km/hr.

It follows from this that the modern fighter pilot can disregard the target speed estimate, especially in the initial phase of air-to-air combat, but must determine its aspect angle as accurately as possible: be able to measure it not in fourths, but in eighths or tenths. The table gives values of angles of approach for the latter instance.

F/A-18 aircraft was approved after a comparison of proposed options; the prime contractor for fulfilling the program was the firm of McDonnell Douglas, with the firm of Northrop as the main subcontractor.

Its first flight took place on 18 November 1978. It took part in combat operations in Libya in April 1986, delivering strikes against ground targets from the carrier "Coral Sea." In addition to the U.S. Navy and Marine Corps, the aircraft is in the inventory of air forces of Canada, Australia and Spain. Other countries also have shown an interest in purchasing it.

There presently are several F/A-18 modifications.

F/A-18A—Initial series-produced single-seat version intended for missions of escort, battlefield interdiction and delivery of strikes against ground targets.

F/A-18B—Two-seat combat trainer (previous designation TF/A-18A).

F/A-18C and F/A-18D—Single-seat and two-seat versions (purchased since 1986). These are more advanced modifications of the aircraft, distinguished from the initial version by installation of additional weapons and new on-board electronics, which considerably expands their combat capabilities. In particular, it is possible to suspend six AIM-120A AMRAAM air-to-air guided missiles and four AGM-65 Maverick air-to-surface guided missiles with IR homing heads as well as an AN/ALQ-165 self-protection active jammer interchangeable with the AN/ALQ-126B. The new XN-6 on-board computer has greater speed and twice the memory of the

XX-5. All aircraft of these modifications, delivered since October 1989, are capable of operating at night in any weather conditions.

**F/A-18RC**—Reconnaissance aircraft equipped with ATARS advance tactical aerial reconnaissance system, which includes optical and infrared sensors installed in the fuselage nose in place of the cannon, and the high-resolution UPD-4 SLAR all-weather side-looking synthetic aperture radar accommodated in a suspended pod.

**CF-18A/B**—Modification for the Canadian Air Force. Has a different instrument landing system, and suspension of pods with LAU-5003 air-launched rockets is provided. AF-18A and ATF-18A are modifications for the Australian Air Force. The EF-18A and EF-18B are modifications for the Spanish Air Force.

In working out configuration principles, basic attention was given to ensuring high aerodynamic efficiency at large angles of attack, increasing maneuverability in close air combat, and preserving stability in a wide range of altitudes and flight speeds.

The aircraft is made with a normal aerodynamic configuration with cantilever mid-wing, twin-fin tail and two engines in the fuselage tail section. The wing folds for storage in the carrier hangar. There are strakes in the wingroot 5.55 m<sup>2</sup> in area supporting the capability of flying at large angles of attack. The wing has developed high-lift devices: leading-edge slats along its entire span, trailing-edge flaps and drooping ailerons. The slats and flaps automatically deflect with the help of servodrives based on signals from the on-board computer depending on angle of attack and Mach number.

The fuselage is a monocoque type. There is an arrestor hook installed in its tail section and a retractable receiving probe for in-flight refueling on the right side in the nose section. Unadjustable semicircular air intakes are located beneath the wingroot along the sides of the fuselage.

The vertical tail consists of two fins displaced considerably forward, which in accordance with the area rule permits reducing aerodynamic drag at supersonic and transonic speeds and keeping them from affecting the stabilizer. The fins are canted 25° outward to reduce the effect of vortices coming off the wingroot strakes.

The aircraft landing gear is tricycle. The front support retracts forward and the main ones backward beneath the channel of the air intakes after the wheels turn 90°.

The power plant consists of two F-404-GE-400 General Electric turbofan engines with power augmentation and a bypass ratio of 0.34 with adjustable nozzle. Static thrust of engines is 2x4900 kg(f), and on afterburner 2x7260 kg(f). Fuel tanks and fuel lines are protected. The capacity of fuselage tanks is approximately 6,435 liters, and it is possible to suspend up to three 1,250 liter fuel tanks.

The flight control system is a digital quadruplex fly-by-wire system. There is backup electric wiring to the

drives of the stabilizer, leading-edge slats, rudder, ailerons and trailing-edge flaps. Additional mechanical control is provided for the stabilizer.

The AN/APG-65 multimode pulse-Doppler radar allows tracking ten targets simultaneously and outputting data on eight targets to the display. The radar operates in air-to-air and air-to-surface modes and supports aiming when firing the cannon, launching guided missiles and bombing. The set's operating frequency band is 8-12.5 kHz and pulse repetition frequency is 1-100 kHz. Acquisition range of a medium-size aircraft is 148 km.

The on-board equipment of the F/A-18 also includes the following systems: AGLS automatic carrier landing system; ARN-118 TACAN inertial navigation system; ARA-63 instrument landing system; APX-100 IFF system; APN-194 radioaltimeter; ALR-67 radar warning system; AN/ALQ-126 EW system; AN/ALE-39 chaff and IR-flare dispenser; and two APC-182 radios (VHF and UHF bands).

When performing strike operations, pods with the AN/AAS-38 forward-looking infrared system and a pod with the LST/TCAM laser target designation system and AN/ASQ-173 panoramic camera can be mounted beneath the air intakes.

Armament is attached to nine hardpoints (one at each wingtip, two beneath each wing panel and three beneath the fuselage). A built-in M61A1 Vulcan 20-mm six-barrel gun with a unit of fire of 570 projectiles is installed in the aircraft. The armament set also includes six AIM-9 Sidewinder air-to-air guided missiles, four AIM-7 Sparrow guided missiles, six AIM-120A AMRAAM guided missiles, four AGM-65E/F Maverick air-to-surface guided missiles, four AGM-88A HARM antiradiation guided missiles; aerial bombs—two B-57 or B-61 atomic bombs, ten Mk 82 free-fall bombs, nine Mk 83, four Mk 84, ten Mk 20 Rockeye or GBU-59/B, two AGM-62 Walleye guided bombs, four GBU-12 guided bombs, four GBU-16/23 guided bombs, and two GBU-18/24 guided bombs; as well as eight free-flight rocket launchers.

When engaging ground targets with aerial bombs, the weapon control system provides a circular error probable of 5-7 m, which is considerably better than the F-4 Phantom's 30 m.

#### F/A-18 Specifications and Performance Characteristics

Wingspan less missiles, m	11.43
Tailplane span, m	6.58
Wing area, m <sup>2</sup>	37.16
Tailplane area, m <sup>2</sup>	8.18
Wheel track, m	3.4
Wheelbase, m	5.42
Weight of empty aircraft, kg	10,455
Takeoff weight, kg:	
Fighter version	16,651



# **F/A-18 Specifications and Performance Characteristics (Continued)**

Attack version	22,328
Weight of combat payload, kg	7,710
Maximum flight speed, km/hr:	
At 11,000 m	1,910 (Mach 1.8)
Near ground	1,350 (Mach 1.0)
Unstick speed, km/hr	250
Carrier landing approach speed, km/hr	248
Service ceiling, m	15,240
Acceleration time from 600 to 1,100 km/hr, seconds	19
Maximum power rate of climb (Mach 0.8, H=1 km), m/sec	193.5
Maximum radius/time of 360° sustained turn, m/sec:	
At 1,000 m	520/25
At 11,000 m	3,000/88
Length of takeoff roll, m	427
Length of landing roll, m	850
Tactical radius, km:	
Fighter version	740
Attack version	1,065
Ferry distance without aerial refueling, km	3,706

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## **Evolution of Foreign Aerial Reconnaissance**

91UM0812I Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
pp 36-37

[Part One of article based on foreign press materials by V. Dubrov, candidate of military sciences, under rubric "In Air Forces of Foreign Armies": "In Search of New Tactics"]

[Text] *The series of articles to be published under this title is devoted to an analysis of the experience of local wars and its use in combat training of air forces of NATO countries. All material was written based on data of foreign sources and was systematized and divided into the following component parts: aerial reconnaissance; tactical command and control; electronic warfare; air defense penetration; air strikes; multiple-aircraft air-to-air combat (engagement). It was in that order that phases were arranged in the U.S. Air Force Linebacker-2 air operation in Vietnam (December 1972), in the "Lebanese" operation in the Near East (June 1982) and in Operation El Dorado Canyon in Libya (April 1986).*

*One should take a critical attitude toward foreign experience of local wars inasmuch as it cannot be transferred wholly to large-scale military conflicts. At the same time,*

*it plays a role of no small importance in air force development, as indicated by the following examples.*

*Back in the early 1960's no one was planning to build the fighters that appeared after the war in Vietnam. Theory also did not forecast the second coming of the attack aircraft. Cessation of the pursuit of altitude and speed, reflected in a "freeze" of these characteristics in third-generation jet aircraft, was unexpected. There were few who expected that supersonic fighter-bombers would suffer at least half of their overall losses from the fire of AAA, retained only due to respect for its past.*

*The pertinence of the experience also is explained by the fact that having passed the "test of fire," a considerable portion of aircraft, weapons, and command and control and support equipment remains operational to this time.*

## **1. Aerial Reconnaissance**

Foreign specialists view aerial reconnaissance from several aspects: as the preliminary phase of an air operation, without which its planning is impossible; as a component part of the electronic countermeasures, air defense penetration and air strike phases; as day-to-day information gathering in support of the army, air force and navy.

The pros and cons of existing aerial reconnaissance means and methods were clearly manifested under combat conditions. There were more negative points. Above all this was the excessively large expenditure of assets for collecting data on the enemy. Thus in 1972, the concluding year of the war in Vietnam, U.S. aircraft flew a total of around 50,000 sorties. Of these, reconnaissance aircraft and auxiliary forces accounted for almost 40 percent, while in World War II no more than 15 percent was spent on performing a similar mission.

The "unproductive" expenditure of forces forced the U.S. command to take a number of urgent steps, which provided for reducing the level of combat losses; automating missions; expanding the functions of reconnaissance subunits; and upgrading the methodology for personnel training.

**Reducing the level of combat losses** became a mandatory consequence of high vulnerability of reconnaissance aircraft to enemy fire. They were first to make an incursion into an unsuppressed air defense system zone and were constrained in maneuver: in performing photography they strictly maintained the flight configuration and became targets. At the beginning of the war in Vietnam RF-101 tactical reconnaissance aircraft suffered considerably greater losses compared with bombers and attack aircraft. The situation changed little with the introduction of the RF-4C Phantom to combat operations, although radiotechnical equipment which automatically determined the bearing to operating acquisition and guidance radars was added to the cameras installed aboard it.

**Automation of missions.** Not just aircraft were destroyed by North Vietnamese air defense weapons. Their crews

often also perished. At the same time, replacement of flight personnel losses proceeded at a slow pace. This was one of the reasons for supplementing manned reconnaissance equipment with reconnaissance drones controlled from the ground or which made a programmed flight. The Firebee vehicles were the most widespread (length 9 m, wingspan 4 m); they were suspended on carrying points of C-130 transport aircraft, delivered to a combat operations area and launched at an operator's command. The programmed flight provided for their execution of a missile-evasion maneuver with up to a 30° bank angle and a g-load up to 5, and photography was accomplished from high or medium altitude. After completing an assignment they would proceed independently to the place for touching down on ground or water, where they landed using brake chutes which opened in succession.

The reconnaissance drones surpassed manned aircraft in survivability because of small dimensions and small visual and radar signature. Their radar acquisition by interceptors in flight was hampered, and they could be picked up visually at a distance of no more than a half-kilometer, especially from rear or forward hemispheres.

The proportion of "unmanned" flights was no more than two percent of the total number of reconnaissance flights. Therefore use of the reconnaissance drones was considered experimental but promising.

With consideration of the experience gained, the U.S. Defense Department allocated appropriations for building reconnaissance drones and upgrading reconnaissance equipment—development of infrared and radar sensors, laser systems with linear scanning, and devices for recording, processing and playing back data. Israel purchased 12 reconnaissance drones and used them in the October War of 1973.

The Israelis used Scout and Mastiff remotely piloted vehicles during the armed conflict in the Near East in June 1982. A television camera (basic version), panoramic camera, and laser rangefinder-target indicator were mounted on them. On commands from the ground, the television camera would scan the Earth's surface in flight within limits of 360° in azimuth and 90° in elevation. The image was transmitted to a data collection point over an automatic line and recorded on a video tape recorder together with data on the time and coordinates of targets discovered. Simultaneously data would go over the automatic line to a command post for assigning a mission to attack aircraft. Specialists included obtaining accurate data on targets on the battlefield in real time among the basic advantages of such a reconnaissance system.

**Expansion of reconnaissance subunit functions.** Coordination with attack aircraft on the battlefield was only one of the additional missions of reconnaissance aircraft. A second mission reflected in regulation documents of U.S. tactical aviation was so-called reconnaissance by fire,

undertaken by joint efforts of tactical strike and reconnaissance aircraft. For example, RF-4C and F-4C aircraft would be included in a common combat formation. The former would seek out a ground target using special equipment and denote it by signaling devices, while the latter would deliver the strike. Both aircraft had identical capabilities to repel attacks by enemy interceptors and to penetrate air defense.

In the Lebanese war in 1982 reconnaissance aircraft were given one more additional mission—decoy actions. Israeli RF-4C aircraft combined ELINT collection with decoy incursions into Syrian air space. Syrian aircraft sent up to intercept them came under attack by Israeli fighters which up to that point had been hiding in "ambush" beyond the lower limit of radar visibility.

Mastiff drones equipped with corner reflectors to reinforce similarity with combat aircraft on radar screens would demonstrate a threat of attack for one-and-a-half or two hours before Israeli group raids on Lebanese targets, keeping Syrian air defense weapon combat teams under constant tension. When their physical fatigue set in, "warmed up" by noontime heat, the real strike would follow.

Close "working" contacts of reconnaissance aircraft were established in local wars not only with tactical strike aviation subunits, but also with fighters, which had an acute need for "deep" air space reconnaissance data. In the Lebanese war this mission was performed by E-2C Hawkeye airborne early warning aircraft with onboard surveillance radars.

Strategic aerial reconnaissance by fast, high-altitude SR-71 aircraft at altitudes of over 21,000 m and at speeds up to 3,200 km/hr beyond limits of SAM system kill zones held a special place in local wars. In one hour of flight each of them would "view" around 150,000 km<sup>2</sup> of the Earth's surface using reconnaissance equipment. An onboard side-looking radar collected data on targets situated at a distance of up to 80 km from the flight route. These aircraft now are being replaced with high-altitude reconnaissance drones. Slow, high-altitude U-2 aircraft performed strategic reconnaissance before the beginning of the six-day Lebanese war.

Automation of the reconnaissance process (especially in the near zone) continues at the present time. The United States has approved a program for developing remotely piloted vehicles with improved "tactical" characteristics. Tactical vehicles being created under the program are divided into four basic types: short-range for observing "over the hills" within a radius of up to 30 km with an endurance of up to six hours at a speed of 185 km/hr; reconnaissance to a depth of up to 150 km to provide the command element with general data on the battlefield alignment of enemy forces; medium-range with a radius up to 650 km, transonic flight speed and two hours endurance; and with a long flight time of up to 24 hours with a radius of action of around 300 km.

Manned reconnaissance aircraft continue to be created based on series combat aircraft. A graphic example is the reconnaissance version of the Tornado ECR fighter-bomber, which accommodates special equipment in place of a gun. It is intended for supporting troops on the FEBA with information about targets in the second echelon of operational alignments of enemy forces.

Both individual as well as joint operations in common combat formations with the strike element are considered identically important in the concept of employing new tactical reconnaissance aircraft. Missions can be performed without entering the kill zone of local air defense weapons or by overcoming the opposition of air defense systems and fighter-interceptors. For this the aircraft has air-to-air and air-to-radar missiles and EW equipment. After modification it also did not lose maneuver capabilities needed for "evasion tactics."

Reconnaissance capabilities of the Tornado compared with its Phantom predecessor are considerably expanded. In addition to traditional elements, the special gear includes forward-looking and side-looking infrared systems. "Thermal" equipment eliminates the "information gap" existing between sensitivity bands of radars and camera gear, providing ordinary photographs of objects with a thermal signature on the surface and beneath the ground, as well as of terrain relief. During field training exercises Tornado ECR crews detected carefully camouflaged objects; uncovered movement routes of transportation equipment from the "trace" resulting from the temperature difference arising due to uneven absorption of thermal energy by the surface; determined the presence of fuel stores in storage areas; distinguished dummy targets from real ones; and recorded engine startups and even the location of field kitchens.

Time periods for submitting intelligence, which as a rule increase with distance from surveillance objects, are one of the constant problems in the reconnaissance area. The United States is solving this problem by using reconnaissance satellites in which electro-optical systems are used in place of cameras. They transmit an image over high-speed data transmission lines using relay satellites. But their cost is very high. Therefore an aerial photoreconnaissance system has been created for transmitting data from any distance within limits of the aircraft's line-of-sight and capable of producing ready-to-use photographs at a ground station 80 seconds after they were taken.

**Upgrading personnel training methodology.** Shortcomings in training flight crews to perform difficult reconnaissance flights are felt acutely against the background of progress achieved in technical spheres of data collection. Effective simulators such as for pilots of other air arms have not yet been created for their training. Reconnaissance personnel are forced to master only theory on the ground, while practice continues to be gained only in

the air. All this affects the results of their actions, and so an active search is in progress for ways of remedying this problem.

(To be continued)

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### **Gorizont Communications Satellite Capabilities**

*91UM0812J Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
pp 42-43*

[Article by Lieutenant-Colonel M. Arkhipov, under rubric "Cosmonautics for the National Economy": "Horizons of the Russian Gorizont"]

[Text] Modern satellite communications is a system of orbiting satellites and a network of ground relay stations. It opened up new opportunities for mankind to exchange information among people at any points on the globe by providing radio telephone and telegraph communications and the transmission of television images. In time the ground television centers basically will support local broadcasts and satellite programs will be received directly by our television sets.

There are now seven Gorizont satellites and stationary receiving and transmitting stations of the Orbita, Ekran and Moskva systems at the disposal of Central Television alone. Specialist evaluations indicate that with the present level of technology it is economically more advantageous to use space and not wire communications at distances over 200 km. Television towers create a zone of positive reception in a radius of only 50-80 km.

Our country occupies one-sixth of the land, and development of space communications is more urgent for it than for any other state. But our proportion of this form of telephone communications is only 4-5 percent, while it is around 7 percent abroad. There are 7.9 million persons in more than 28,000 communities of European Russia unable to receive television broadcasts, an average of only every fourth family in the republic has telephones installed, and many communication lines are overloaded.

The RSFSR Council of Ministers saw that the decision was made to purchase, launch and operate three Gorizont communications satellites with its budget funds. It is not superfluous to say that such spacecraft are fabricated in Krasnoyarsk and the four-stage Proton booster rocket is made by the Moscow Machine Building Plant imeni M. V. Khrunichev.

The first Russian satellite was launched from the Baykonur Space Launch Center on 23 November 1990 by a launch team of one of the USSR Ministry of Defense space units. The Ussuri, Ulan-Ude, Kolpashevo and other facilities of their space command, control and telemetry complex assumed subsequent control.

[Portion of text possibly missing due to typographical error] when the Gorizont was in the Southern Hemisphere a motor was started which shifted it from a circular base orbit to a highly elliptical transfer orbit with an inclination of  $47^\circ$ . The next ignition occurred strictly according to the flight program, when the spacecraft had moved into the Northern Hemisphere and was over the Equator. Thus in a seven-hour period it was transferred to a geostationary orbit 36,000 km high, then over a period of 22 days to the calculated point at 40 degrees east longitude. Here the first Russian Gorizont satellite stands its watch, stationary relative to the Earth's surface.

The spacecraft of this series appeared in space 12 years ago. The satellite is a cylinder 5 m high and 2 m in diameter weighing 2,200 kg. Antenna reflectors and altitude monitoring sensors are mounted on its lower part facing the Earth's surface. Two extended solar battery panels have a span up to 10 m. The guaranteed operating life is 3 years. The relay is the basic functional element. It contains eight high-frequency transceiver channels, which permits successfully transmitting signals to Earth of television, multichannel and limited-channel telephone-telegraph communications, radio broadcasting, and newspaper page images. The gear's radiating power is up to 40 watts, which provides a rather high signal level at ground receiving antennas. The satellite is

equipped with a three-axis system of precise orientation on Earth and with systems for thermal regulation and power supply with independent orientation of photo cell panels on the Sun.

Gorizont's technical outfitting enables not only bringing television into each home, but also providing radiotelephone communications to geological prospectors, hunters, drivers on long trips, reindeer breeders and shepherds. And installation of an additional Volna relay will allow organizing conversations with fishing vessels on the high seas and with aircraft. The satellite's highly directional emitters are used to transmit television programs to simplified ground receiving antennas 2.5 m in diameter for individual use which can be set up in any place. The design of such a station also provides an opportunity for interface with a cable distribution network.

The second and third satellites will become operational this year and the following year. Situated at points of 40, 103 and  $145^\circ$  east longitude, they will form five-zone broadcasting of two programs throughout republic territory, on which there already is an entire relay network. Thus, fixed television centers of varying output will receive signals from space and transmit them to television receivers. The aforementioned spherical antennas for direct reception of television broadcasts from the

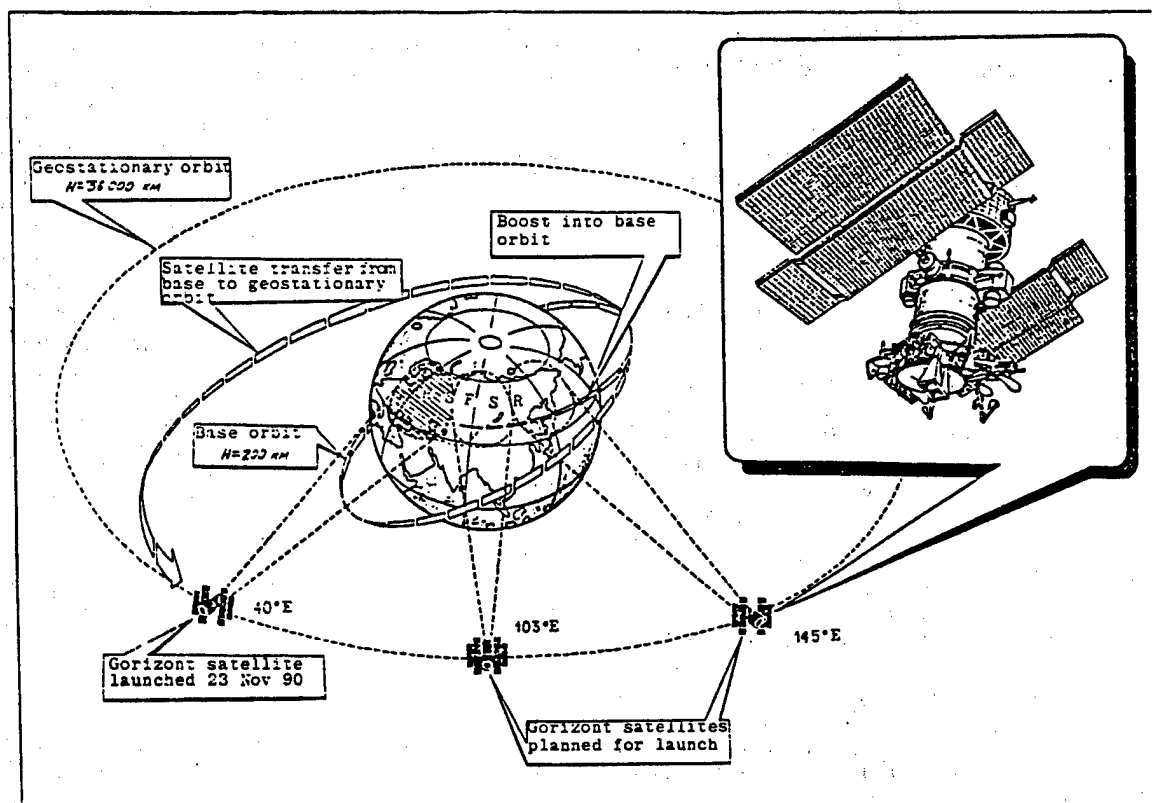


Diagram of Gorizont satellite insertion into geostationary orbit

satellite are expensive for now; they just have begun being made, but they are what will enable anyone who wishes to do so to watch television.

There will be a substantial simultaneous increase in quality, efficiency and volume of telephone-telegraph communications, although full satisfaction of the requirement is still far off. It is not by chance that plans of the RSFSR Ministry for Communications, Information and Space includes bringing the number of its communications satellites to 10. This is one of the important elements of Russia's real sovereignty.

Just what will the first phase cost? The price is formed above all from the cost of the satellite—R8-12 million, the cost of the launch—R7 million and operating expenses—approximately R2.5 million per year. On the whole, it will be necessary to pay the Ministry of General Machine Building and the Ministry of Defense R65-80 million for three operating Gorizonts—50 kopecks per person in all. And how many problems will be solved all at once!

And so Russia is the first. Now it is necessary to legislatively specify the procedure and rules for use of satellites by any republic and perhaps by an organization or firm. This will permit realistically evaluating the contribution of cosmonautics to the national economy, and it will constantly grow as technology develops and the range of tasks expands. It is already time for us as well to become part of the international Intelsat system.

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### **Kristall Module of Mir Space Station Described**

*91UM0812K Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 91 (signed to press 19 Mar 91) pp 46-47*

[Article by G. Sergeyev, under rubric "On the Path to a Space Plant": "The Kristall"]

[Text] The Kristall is the third specialized module of the Mir modular space station; it became part of it on 10 June 1990. The numerous pieces of equipment it delivered allow not only broadening the spectrum and scope of scientific research and experiments, but also increasing the modular space station's functional capabilities and supporting the testing of advanced elements of space technology.

One can judge the scale and direction of scientific experiments according to the makeup of equipment and gear accommodated in the bays of this docking-technological module. The Kristall will be a space shuttle "berth." Its second function is to enable working out space technologies; obtaining test lots of materials (the Zona and Kristallizator ChSK-1 units), semiconductors (the Krater-V and Optizon-1 units) and biological specimens (Aynur complex); as well as performing various geophysical and astrophysical experiments.

The Kristall largely is standardized with its predecessor, Kvant-2, in design. It has the same outfitting with devices permitting it to approach the station independently and take its place: autonomous radio systems, propulsion unit, control and approach systems, docking devices, and a redocking manipulator. The basis of the spacecraft's design and its configuration also are similar; true, there is the difference that the periphery of the Kvant-2 module has bays for an airlock and for providing egress to open space, while the Kristall has a bay with additional docking devices.

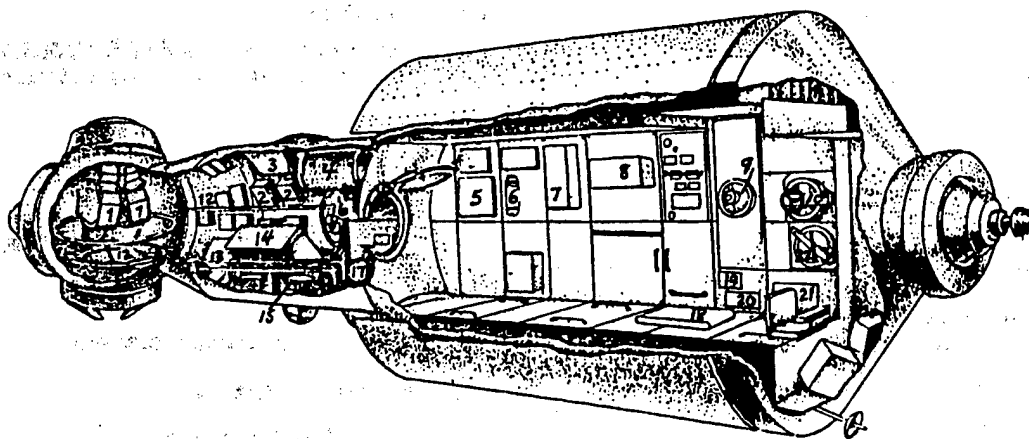
The new module has a sum total of three docking units. One is for docking with the station and the others, of an androgynous type, are for mating other spacecraft to the complex. The design of these units is based on the same principles as were tested in the Soyuz-Apollo project, but they have been considerably modernized: lightweight, more reliable, and with certain improvements. The one situated on the module axis is for docking the Buran spacecraft and another on the side is for additional modules it delivers. In operating the Mir complex together with such winged space shuttles in the future it is planned to periodically change the specialized modules on this lateral assembly. The operation will be performed by its onboard manipulator. Docking with an aerospace vehicle will occur once or twice a year, and at that time it is planned to redock the Kristall module on the station's axial assembly.

Such an equipment replacement will give the entire modular space station a new quality and provide an opportunity for ground servicing of costly gear.

Another feature of the new module is the solar batteries capable of opening up and reaching a length of 15 m. Developing the design of these batteries' mechanisms so as to ensure necessary operating reliability under space conditions required original engineering solutions and lengthy experimental work. The Mir's usual orientation is such that it creates a probability of lengthy shading of the solar batteries. Therefore the design capability for compactly folding the Kristall's photo cell panels and subsequently transferring them to a more convenient place on the Kvant module was included in advance. This serious operation of installing equipment is performed by cosmonauts in extravehicular activity. To ensure effective battery operation it is necessary to install special trusses, set up electric drives on them and run power and control cables.

The opening mechanism was given an experimental check of working capacity in the very first revolutions after the Kristall was inserted into orbit. The batteries were opened to a third of their span, then another third. The process was completed after the Kristall was redocked to the modular space station's lateral assembly. All operations took place without adverse comment.

The independent flight to the Mir essentially was performed faultlessly, but still in the final long-range closing



## Key:

- |   |   |
|---|---|
| 1. SA-20M, SAM-20-11 cameras                          | 12. Handrail  |
| 2. Units of Marina gear                               | 13. Companionway                                    |
| 3. TUB thermostat                                     | 14. TSB thermostat                                  |
| 4. Onboard cooling unit with automatic equipment unit | 15. Kseniya unit                                    |
| 5. TV cable stowage                                   | 16. Solar battery drive                             |
| 6. Fire extinguisher                                  | 17. Airlock chamber                                 |
| 7. Stowage of Krater V materials                      | 18. Running track                                   |
| 8. Stowage of Optizon-1 materials                     | 19. Set of packaged UZ03 samples (for Zona 03 unit) |
| 9. Optizon-1 electric oven                            | 20. Set of packaged UZ02 samples (for Zona 02 unit) |
| 10. Zona 03 unit                                      | 21. Case for onboard documents                      |
| 11. Cargo containers                                  | 22. Zona 02 unit                                    |

phase the control system formed a command for stopping the process due to abnormal operation of an attitude control motor. Let us recall that there have been surprises during docking for each of the modules now operating in space. Nevertheless, in all cases success was achieved through common efforts of control system developers, mission control specialists and cosmonauts. That occurred this time as well. True, the operation was not completed within the planned time and a new pass and docking approach were made on the reserve set of motors.

And so the Mir manned space station is functioning in orbit with specialized modules constantly in its makeup: the Kvant astrophysical module, Kvant-2 re-equipping module, and the Kristall docking-technological module. Such equipment permits making ever wider use of achievements and advantages of cosmonautics and bringing more and more benefit to the national economy.

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in Russian No 3, Mar 91 (signed to press 19 Mar 91)  
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#### Publication Data

91UM0812M Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3, Mar 91 (signed to press 19 Mar 91)

[Text]

English title: Aviation and Cosmonautics

Russian title: AVIATSIYA I KOSMONAVTIKA

Editor: V. V. Anuchin

Publishing house: Voennoye izdatelstvo

Place of publication: Moscow

Date of publication: March 1991

Signed to press: 19 March 1991

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